

# Multiscale Clustering of Spatiotemporal Signals: Application to the Analysis of fMRI Data

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High dimensional spatiotemporal datasets are routinely acquired in many areas of biology and medicine. These datasets have a particular structure : they are composed of temporal signals  $s(x; t)$  that are indexed by their position  $x$ . A time series of functional Magnetic Resonance Images (fMRI) is an example of such datasets. fMRI can quantify hemodynamic changes induced by neuronal activity when a subject is submitted to sensory or cognitive stimulations. The goal of the analysis is to detect the “activated” voxels  $x$  where the changes in the fMRI signal can be considered to be triggered by the stimulus. In this work we explore a new paradigm for the analysis of fMRI data. In the absence of any detailed substantive understanding of the mechanism of the fMRI response, we advocate a nonparametric approach that can better account for all important features present in the data. The principle of our approach is illustrated in Fig. 1-left. For each voxel  $x_0$  inside the brain we consider a 3-dimensional window  $W_{x_0}$  around  $x_0$ , and we partition the time series originating from the voxels inside  $W_{x_0}$ . If  $W_{x_0}$  is located in a part of the brain that is activated, then one of the two clusters encompasses the activated voxels, or activated time series. The other cluster contains time series that correspond to background activity. If the window is in a part of the brain with no activity correlated to the stimulus, then all time series are considered to be background activity. Because of the curse of dimensionality, the clustering of the time series cannot be performed directly in the time domain. The dimensionality of the signal space is reduced by projecting the time series on a low dimensional subspace. The subspace is composed of wave-forms selected from a large dictionary of wavelet packets for their ability to partition the projected time series into two groups. We performed in [1] a systematic comparison of the performance of our approach with other standard methods using synthetic and *in-vivo* fMRI datasets. Fig. 1-a illustrates the ability of our method to cluster time series using only two clustering functions. The scatter plot represents the projections of 16 time series on the two best clustering functions. The time series were extracted from a window  $W_{x_0}$  placed in the prefrontal cortex (the data provided by Dr. Gregory McCarthy, Duke University, demonstrate prefrontal cortex activation in the presence of infrequent events). The activated cluster (\*) is well separated from the background cluster (+). Fig. 1-b shows an activation map for this experiment. The construction of the “clustering basis functions” described in this work is applicable to a large category of problems in biology where one needs to identify relevant features in order to cluster vectors in a large dimensional space.

## Reference

1. Meyer, F. and Chinrungrueng, J. *IEEE Trans. on Medical Imaging* **22(8)**, 933–939 (2003).

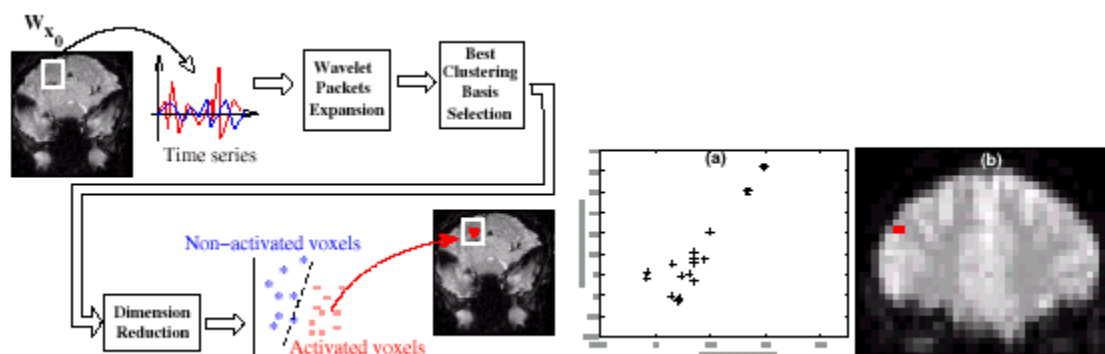


Figure 1: Left: Principle of the analysis. Right: (a) Scatter plot, (b) Activation map.